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NICOTINE INSECTICIDES. Part V--SEARCH FOR SYNERGISTS

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This paper is the fifth in a series reporting investigations on nicotine insecticides (see E-646, E-709, E-720, and E-725). In Part II (E-709) an effort was made to find compounds that might replace part of the nicotine to stretch the limited supply of this insecticide and thereby make its use more economical. This paper is a continuation of such studies and presents results obtained with 107 additional materials. As before, all mixtures were prepared at the Eastern Regional Research Laboratory of the Bureau of Agricultural and Industrial Chemistry and tested against plant-feeding insects at the Sanford (Fla.) and Anaheim (Calif.) laboratories of the Bureau of Entomology and Plant Quarantine.

Some of the compounds used here have been tested alone as insecticides. Swingle, Phillips, and Gahan (7, 8) showed that phthalonitrile and 1,4-diphenylsemicarbazide were as good stomach insecticides as lead arsenate and that, in general, phthalonitrile was superior to derris and pyrethrum, with which it was also compared. Gahan, Swingle, and Phillips (2) also showed that 1,4-diphenylsemicarbazide was more toxic than lead arsenate and derris to the melonworm and the southern beet webworm, and about equal to the two materials against the Hawaiian beet webworm and the southern armyworm. Phthalonitrile (Schechter and Haller 5) and 1,4-diphenylsemicarbazide (Freeman 1) have been patented as insecticides. Läuger (3) showed that bis(p-chlorophenyl) sulfide was highly toxic to clothes moths.

1/ Now with Office of Experiment Stations.

2/ This work was conducted under the general supervision of G. T. Bottger. A. P. Yerington and Carl Robertson helped with the rearing of insects and the testing of insecticides.

Materials and Methods

In this study each sample contained 5 percent of adjunct plus only 2 percent of nicotine as the sulfate, whereas 5 percent of nicotine was used previously. All mixtures were compared with dusts containing 5 percent and 2 percent of nicotine except when used against the pea aphid, when 3.5 percent and 2 percent of nicotine were used. Most of the mixtures contained attapulgite as the diluent. This material was found to be an excellent carrier for nicotine, because of its ability to adsorb large amounts of liquid, its dustability, and its tendency to increase mortalities (E-720). Several materials were compared with each other in three carriers--attapulgite, bentonite, and pyrophyllite. As in Part II, the adjuncts were chosen at random.

Several species of lepidopterous larvae, three species of aphids, and the large milkweed bug were used as the test insects. The insects and stages used were first instars of the southern armyworm (Prodenia eridania (Cram.)) and the variegated cutworm (Peridroma margaritosa (Haw.)); third instars of the diamondback moth (Plutella maculipennis (Curt.)); fourth instars of the melonworm (Diaphania hyalinata (L.)), the Hawaiian beet webworm (Hymenia recurvalis (F.)), the armyworm (Cirphis unipuncta (Haw.)), and the beet armyworm (Laphygma exigua (Hbn.)); all stages of field-collected bean aphids (Aphis fabae Scop.) and green peach aphids (Myzus persicae (Sulz.)); and 1-day-old nymphs of the pea aphid (Macrosiphum pisi (Kltb.)); and third and fourth nymphal stages of the large milkweed bug (Oncopeltus fasciatus (Dall.)).

The testing procedures were similar to those described by Swingle (6) and in Part 1 of this series. The materials were tested by infesting dusted foliage with first-instar larvae in cloth-covered vials and third- and fourth-instar larvae in 9-cm. petri dishes. The aphids were dusted or sprayed directly on the plants on which they were feeding and were then confined in 16.5-cm. battery jars with cloth caps. The large milkweed bugs were dusted in 7.5-cm. crystallizing dishes covered with cloth tops. The deposits usually ranged between 100 and 200 micrograms per square centimeter. About 30 larvae, 25 nymphs of the large milkweed bug, and 40 or more aphids were used in each test. Each material was tested against from 2 to 9 species. Mortality counts on the leaf-feeding larvae and the large milkweed bug were made after 3 days and those on the aphids after 2 days.

Most of this report deals with toxicants applied as dusts. If the results showed that the mixture was worthy of further testing, phytotoxicity and spray tests were run.

Discussion of Results

Where any mixture of nicotine and adjunct (table 1, A) gave higher mortality than that given by the 5-percent nicotine standard alone (table 1, B) against two or more insect species, the adjunct was considered to be

a possible synergist of the nicotine. By this criterion the compounds given in table 1 appeared to be the most promising. This table also presents mortalities caused by dusts containing 2 percent of nicotine (C) and 5 percent of adjunct (D) when used alone, and the additive kills of these two (C + D).

On the basis of comparison with the 5-percent nicotine (column A-B), the most effective adjuncts were p-bromobenzenesulfonamide, bis(p-chlorophenyl) sulfide, 1,4-diphenylsemicarbazide, 2,3,4,5,6-pentachloroanisole, pentaerythritol diisobutyral, phenyl sulfide, phthalonitrile, and 2-stilbazole. On the basis of comparison with the additive effects (column C + D), the most effective adjuncts were bis(p-chlorophenyl) sulfide in bentonite, 2,4-dinitromesitylene, pentaerythritol diisobutyral, phthalonitrile, pentachlorocumene, and 2-stilbazole. However, comparisons cannot be made with all materials owing to lack of data. 2,4-Dinitromesitylene in combination with nicotine was better than the 5-percent nicotine against only two out of eight insects, but against the six insects in the additive effect (C + D) it appeared promising.

Whether or not a given adjunct is more toxic in itself than the 5-percent nicotine is no indication of the effect when it is mixed with nicotine. In tests against the armyworm, phthalonitrile alone gave 55 percent greater kill than nicotine, but against the pea aphid it gave 34 percent less. Synergism was definitely demostrated against both these insects in later unpublished quantitative experiments and in McGovran et al. (4)

Phenyl sulfide when used alone was not effective against any of three species of aphids. However, in mixture with nicotine it showed possible synergism against two of the species.

Table 2 gives the results of tests against pea aphids. Where comparisons of mixture and additive kills may be made, there are eight adjuncts that show promise as synergists.

The 35 adjuncts in mixtures that were superior to nicotine against at least one insect are shown in table 3. The other 72, which were ineffective against every insect tested, are given in table 4.

Of six adjuncts related to 2,3,4,5,6-pentachloroanisole, four were effective in mixtures against the southern armyworm but not against the melonworm, and the other two were ineffective against both species. None of these materials were toxic in themselves to either the melonworm or the southern armyworm, whereas 2,3,4,5,6-pentachloroanisole was toxic to these species.

Nine adjuncts related to phthalonitrile were tested. Four were effective in mixtures against the pea aphid, and one of the four, tridecanenitrile, was also effective against the armyworm but not the diamondback moth. All others were ineffective against two insects, the pea aphid and a leaf-feeding larva.

Of three materials tested for phytotoxicity, bis(p-chlorophenyl) sulfide, 2,3,4,5,6-pentachloroanisole, and phthalonitrile--none caused

any injury to at least five kinds of plants. These materials were tested separately and also in combination with nicotine.

Since the adjuncts listed in table 1 show possible synergism, they will be subjected to more comprehensive and quantitative tests, the data from which can be calculated for synergism according to Wadley's (9) method. This has already been done in the case of phthalonitrile (McGovran, Mayer, and Talley 4) and 2,3,4,5,6-pentachloroanisole.

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Table 1. - Mortality data on the 15 compounds that show promise of synergism with nicotine.

Adjunct and insect (diluent attapulgite unless otherwise indicated)	Deposit of dust, micrograms per square centimeter	Extent of feeding	Mortality (percent)					
			Mixture	Nicotine alone		Adjunct alone 5 percent	Additive effect	Above or below 5 percent nicotine
				5 percent	2 percent			
			(A)	(B)	(C)	(D)	(C+D)	(A-B)
p-Bromobenzene sulfonamide:								
Armyworm (3) 2/	107	Trace	75	39	14	64	78	+36
Diamondback moth	140	--do--	43	88	70	73	143	-45
Green peach aphid	170	-	16	83	19	0	19	-67
Melonworm (2)	100	Moderate	69	64	-	-	-	+ 5
Pea aphid	100	-	73	82 1/	81	0	81	- 9
Southern armyworm (2)	100	Trace	73	39	-	-	-	+34
Variegated cutworm (2)	198	--do--	98	90	59	78	137	+ 8
Cetyl ether:								
Armyworm	100	Moderate	21	88	32	5	37	-67
Beet armyworm	195	--do--	65	71	52	8	60	- 6
Diamondback moth	160	--do--	63	100	50	46	96	-37
Green peach aphid	170	-	16	90	37	50	87	-74
Melonworm	105	Moderate	22	63	46	-	-	-41
Pea aphid	100	-	96	82	81	0	81	+14
Southern armyworm	100	Trace	100	92	76	-	-	+ 8
Bis(p-chlorophenyl) sulfide in pyrophyllite:								
Hawaiian beet webworm (2)	143	--do--	96	85	29	85	114	+11
Large milkweed bug	125	-	48	100	-	-	-	-52
Melonworm (3)	163	Moderate	42	45	18	8	26	- 3
	0.1% 3/	--do--	86	59	-	-	-	+27
Southern armyworm (2)	75	None	100	21	21	100	121	+78
	0.1%	Trace	100	0	-	-	-	+100

1/ 3.5 percent of nicotine.
2/ Figures in parentheses indicate number of tests if more than one.
3/ Figures in percent indicate the strength of nicotine in a spray test.

Table 1. -(Continued)

Adjunct and insect (diluent attapulgite unless otherwise indicated)	Deposit of dust, micrograms per square centimeter	Extent of feeding	Mortality (percent)					
			Mixture	Nicotine alone:		Adjunct alone	Additive effect	Above or below 5 percent nicotine
				5 percent	2 percent	5 percent		
			(A)	(B)	(C)	(D)	(C+D)	(A-B)
Bis(p-chlorophenyl) sulfide in bentonite:								
Hawaiian beet webworm	140	Trace	96	95	26	-	-	+ 1
Melonworm (3)	150	Moderate	55	59	13	13	26	- 4
Southern armyworm (3)	85	None	100	39	28	0	28	+61
Bis(p-chlorophenyl) sulfide in attapulgite:								
Hawaiian beet webworm	155	--do--	100	67	36	-	-	+33
Melonworm	165	Moderate	42	50	10	-	-	- 8
Southern armyworm	63	None	100	41	37	-	-	+59
2-Cyclohexylcyclohexylamine:								
Armyworm	130	Moderate	77	80	44	-	-	- 3
Diamondback moth	111	--do--	44	68	36	-	-	-24
Pea aphid	95	-	86	80	16	-	-	+ 6
2,4-Dinitromesitylene:								
Armyworm (2)	108	Moderate	40	45	16	26	42	- 5
Beet armyworm	210	None	100	89	23	76	99	+11
Diamondback moth	135	Moderate	26	75	23	0	23	-49
Green peach aphid	170	-	49	83	19	2	21	-34
Melonworm	200	Moderate	32	63	29	-	-	-31
Pea aphid	120	-	73	86	46	13	59	-13
Southern armyworm (2)	100	None	100	86	46	-	-	+14
Variegated cutworm	210	Moderate	61	97	55	7	62	-36

Table 1. - (Continued)

Adjunct and insect (diluent attapulgite unless otherwise indicated)	Deposit of dust, micrograms per square centimeter	Extent of feeding	Mortality (percent)					
			Mixture (A)	Nicotine alone		Adjunct alone 5 percent (D)	Additive effect (C+D)	Above or below 5 percent nicotine (A-B)
				5 percent (B)	2 percent (C)			
2,4-Dinitrophenyl 2,3,4,5,6-pentachlorophenyl ether:								
Diamondback moth	103	Moderate	0	60	-	-	-	-60
Melonworm (2)	105	--do--	32	40	15	0	15	- 8
Pea aphid (3)	95	-	40	47	29	-	-	- 7
Southern armyworm	103	Moderate	88	82	65	36	101	+ 6
1,4-Diphenylsemicarbazide:								
Armyworm (2)	90	--do--	48	28	5	77	82	+20
Diamondback moth	140	--do--	50	88	70	50	120	-38
Green peach aphid	210	-	11	89	23	14	37	-78
Melonworm	100	Moderate	77	33	5	-	-	+44
Pea aphid (2)	100	-	80	77	59	93	152	+ 3
Southern armyworm	100	Trace	100	82	41	-	-	+18
Variegated cutworm	200	None	100	38	5	100	105	+62
2,3,4,5,6-Pentachloroanisole:								
Diamondback moth	100	Trace	88	60	0	-	-	+28
Large milkweed bug	140	-	12	23	-	-	-	-11
Melonworm (5)	137	Moderate	95	40	18	99	117	+55
Pea aphid (6)	100	-	75	47	29	-	-	+28
Southern armyworm	118	Trace	92	65	43	97	140	+27

Table 1. - (Continued)

Adjunct and insect (diluent attapulgite unless otherwise indicated)	Deposit of dust, micrograms per square centimeter	Extent of feeding	Mortality (percent)					
			Mixture (A)	Nicotine alone 5 percent (B)	Nicotine alone 2 percent (C)	Adjunct alone 5 percent (D)	Additive effect (C+D)	Above or below 5 percent nicotine (A-B)
Pentachlorocumene:								
Armyworm	100	Trace	96	88	32	50	82	+ 8
	0.1%	Moderate	0	48	20	0	20	-48
Bean aphid	0.0025%	-	71	88	71	3	74	-17
Beet armyworm	205	Trace	100	67	30	70	100	+33
Diamondback moth	135	Moderate	32	75	23	0	23	-43
Green peach aphid	170	-	5	83	19	0	19	-78
Melonworm	115	Moderate	22	63	46	-	-	-41
Pea aphid	100	-	63	86	46	35	81	-23
Southern armyworm	110	Trace	95	92	80	-	-	+ 3
Variegated cutworm	200	--do--	83	98	55	13	68	-15
Pentaerythritol diisobutyral:								
Armyworm (3)	105	--do--	80	57	35	45	80	+23
	0.1%	--do--	87	70	-	-	-	+17
Beet armyworm	200	None	100	67	30	44	74	+33
Diamondback moth	155	--do--	96	100	50	26	76	- 4
Green peach aphid	170	-	53	90	37	38	75	-37
Melonworm	110	Moderate	42	63	46	-	-	-21
Pea aphid	100	-	98	82	81	0	81	+16
Southern armyworm	110	Trace	96	92	80	-	-	+ 4
Variegated cutworm (2)	233	--do--	62	29	5	54	59	+33

Table 1. - (Continued)

Adjunct and insect (diluent attapulgite unless otherwise indicated)	Deposit of dust, micrograms per square centimeter	Extent of feeding	Mortality (percent)					
			Mixture (A)	Nicotine alone 5 percent (B)	Nicotine alone 2 percent (C)	Adjunct alone 5 percent (D)	Additive effect (C+D)	Above or below 5 percent nicotine (A-B)
Phenyl sulfide:								
Armyworm (3)	98	None	100	40	9	93	102	+60
	0.1%	--do--	100	48	20	97	117	+52
Bean aphid	0.0025%	-	66	88	71	4	75	-22
Beet armyworm	205	None	100	89	23	100	123	+11
Diamondback moth (2)	140	--do--	95	55	38	59	97	+40
Green peach aphid	165	-	32	83	19	9	28	-51
Melonworm (2)	108	Moderate	40	58	30	-	-	-18
Pea aphid	100	-	100	86	46	0	46	+14
Southern armyworm	100	None	100	85	64	-	-	+15
Variegated cutworm	200	--do--	100	67	39	67	106	+33
Phthalonitrile:								
Armyworm (3)	80	--do--	100	21	4	76	80	+79
	0.1%	--do--	100	70	-	-	-	+30
Diamondback moth	140	--do--	100	75	23	39	62	+25
Green peach aphid	200	-	76	89	23	41	64	-13
Melonworm	100	None	100	33	5	-	-	+67
Pea aphid	105	-	96	47	29	13	42	+49
Southern armyworm	100	None	100	72	6	-	-	+28
Variegated cutworm (2)	200	--do--	100	90	58	80	138	+10

Table 1. - (Continued)

Adjunct and insect (diluent attapulgite unless otherwise indicated)	Deposit of dust, micrograms per square centimeter	Extent of feeding	Mortality (percent)					
			Mixture (A)	Nicotine alone 5 percent (B)	Nicotine alone 2 percent (C)	Adjunct alone 5 percent (D)	Additive effect (C+D)	Above or below 5 percent nicotine (A-B)
Sesmin:								
Armyworm	100	Moderate	35	88	32	14	46	-53
Beet armyworm	200	--do--	46	71	52	32	84	-25
Diamondback moth	155	--do--	70	100	50	23	73	-30
Green peach aphid	170	-	26	90	37	9	46	-64
Melonworm	110	Moderate	76	63	46	-	-	+13
Pea aphid	100	-	97	82	81	0	81	+15
Southern armyworm	115	Trace	85	92	80	-	-	- 7
Variegated cutworm	185	Moderate	3	23	7	3	10	-20
2-Stilbazole:								
Armyworm	100	--do--	8	41	10	21	31	-33
Beet armyworm	200	Trace	92	71	52	50	102	+21
Diamondback moth	140	Moderate	0	75	23	0	23	-75
Green peach aphid	200	-	64	89	23	8	31	-25
Melonworm	180	Moderate	33	42	7	-	-	- 9
Pea aphid	100	-	94	82	81	8	89	+12
Southern armyworm (2)	95	Moderate	88	85	46	-	-	+ 3
Variegated cutworm (2)	233	--do--	47	29	5	36	41	+18
Tridecanenitrile: 4/								
Armyworm (3)	102	Moderate	56	54	15	-	-	+ 2
Diamondback moth	95	--do--	13	60	0	-	-	-47
Pea aphid (2)	103	-	66	62	25	-	-	+ 4

4/ Related to phthalonitrile. Other footnotes on page 6.

Table 2. - Mortality data on (A) dust mixture containing 2 percent of nicotine and 5 percent of adjunct, (B) 3.5 of nicotine alone and (C) 2 percent of nicotine alone, and (D) 5 percent of adjunct alone, all applied against the pea aphid.

Adjunct	Deposit of dusts, micrograms per square centimeter	Mortality (percent)					
		Mixture	Nicotine alone		Adjunct alone 5 percent	Additive effect	Above or below 3.5 percent nicotine
			3.5 percent	2 percent			
		(A)	(B)	(C)	(D)	(C+D)	(A-B)
γ-Acetyl-γ-(2-cyanoethyl)-pimelonitrile [1]	155	100	97	68	-	-	+ 3
p-Bromobenzenesulfonamide	100	73	82	81	0	81	- 9
4-Caproylmorpholine	100	100	94	11	-	-	+ 6
4-Caprylylmorpholine	105	76	56	5	-	-	+20
Cetyl ether	100	96	82	81	0	81	+14
Bis-(2-cyanoethyl ether [1]	95	81	52	50	-	-	+29
2-Cyclohexylcyclohexylamine	95	86	80	16	-	-	+ 6
2,4-Dinitromesitylene	120	73	86	46	13	59	-13
1,4-Diphenylsemicarbazide	100	80	77	59	93	152	+ 3
1-Dodecanethiol	105	21	86	46	2	48	-65
3-Methyl-2,4 pentanediol	95	96	80	16	-	-	+16
2,3,4,5,6-Pentachloroanisole	100	75	47	29	-	-	+28
Pentachlorocumene	100	63	86	46	35	81	-23
Pentaerythritol diacetal	100	32	83	17 [2]	3	20	-51
Pentaerythritol diisobutyral	100	98	82	81	0	81	+16
p-Phenylazoanile	100	69	82	81	0	81	-13
Phenyl sulfide	100	100	86	46	0	46	+14
Phthalonitrile	105	96	47	29	13	42	+49
Sesamin	100	97	82	81	0	81	+15
2-Stilbazole	100	94	82	81	8	89	+12
Tridecanenitrile [1]	103 [3]	66	62	25	2	27	+ 4

[1] Related to phthalonitrile.
[2] 1 percent of nicotine.
[3] Average of 2 tests.

Table 3. - Adjuncts in mixture with nicotine showing promise of synergistic action against at least one species. (xx indicates apparent synergism, x no snyergism, and - no test made.)

Adjunct	Bean aphid	Green peach aphid	Pea aphid	Armyworm	Beet armyworm	Southern armyworm	Diamondback moth	Hawaiian beet webworm	Melonworm	Large milkweed bug	Variegated cutworm
γ-Acetyl-γ-(2-cyanoethyl)pimelonitrile [1]	-	-	xx	x	-	-	x	-	-	-	-
Bis(2-cyanoethyl) ether [1]	-	-	xx	x	-	-	-	-	-	-	-
p-Bromobenzenesulfonamide	-	x	x	xx	-	xx	x	-	xx	-	xx
p-Bromo-N-isobutylbenzenesulfonamide	-	-	-	-	-	xx	-	-	x	-	-
(1)2,3-Butylene glycol	-	-	xx	x	-	-	x	-	-	-	-
4-Caproyl morpholine	-	-	xx	x	-	-	x	-	-	-	-
4-Caprylyl morpholine	-	-	xx	-	-	-	x	-	-	-	-
6-Carbobutoxy-3,4-dihydro-2,2-dimethyl-4-oxo-1,2-pyran	-	-	-	-	-	xx	-	-	x	-	-
Cetyl ether	-	x	xx	x	x	xx	x	-	x	-	-
1-(4-Chlorophenoxy) dodecane [2]	-	-	-	-	-	xx	-	-	x	-	-
Bis(p-Chlorophenyl) sulfide in-											
Pyrophyllite	-	-	-	-	-	xx	-	xx	x	x	-
Bentonite	-	-	-	-	-	xx	-	xx	x	-	-
Attapulgite	-	-	-	-	-	xx	-	xx	x	-	-
2-Cyclohexylcyclohexylamine	-	-	xx	x	-	-	x	-	-	-	-
2,4-Dinitromesitylene	-	x	x	x	xx	xx	x	-	x	-	x
2,4-Dinitrophenyl-2,3,4,5,6-pentachlorophenyl ether [2]	-	-	x	-	-	xx	x	-	x	-	-
1,4-Diphenylsemicarbazide	-	x	x	xx	-	xx	x	-	xx	-	xx

1/ Related to phthalonitrile.
2/ Related to 2,3,4,5,6-pentachloroanisole.

Adjunct	Bean aphid	Green peach aphid	Pea aphid	Armyworm	Beet armyworm	Southern armyworm	Diamondback moth	Hawaiian beet webworm	Melonworm	Large milkweed bug	Variegated cutworm
1-Dodecanethiol	x	x	x	x	x	xx	x	-	x	-	-
Dodecyl acetoacetate in -											
Bentonite	-	-	-	-	-	xx	-	-	x	-	-
Pyrophyllite	-	-	-	-	-	xx	-	-	x	-	-
Attapulgite	-	-	-	-	-	x	-	-	x	-	-
Tridecanenitrile [1]	-	-	xx	xx	-	-	x	-	-	-	-
2-(2-Methoxyethoxy)ethanol in -											
Bentonite	-	-	-	-	-	xx	-	-	x	-	-
Pyrophyllite	-	-	-	-	-	x	-	-	x	-	-
Attapulgite	-	-	-	-	-	xx	-	-	x	-	-
3-Methyl-2,4-pentanediol	-	-	xx	x	-	-	x	-	-	-	-
4'-Nitro-2-stilbazole	-	-	-	-	-	x	-	-	xx	-	-
2,3,4,5,6-Pentachloroanisole	-	-	xx	-	-	xx	xx	-	xx	x	-
Pentachlorocumene	x	x	x	xx	xx	xx	x	-	x	-	x
1-(2,3,4,5,6-Pentachlorophenoxy)-octadecane [2]	-	-	-	-	-	xx	-	-	x	-	-
1-(2,3,4,5,6-Pentachlorophenoxy)-dodecane [2]	-	-	-	-	-	xx	-	-	x	-	-
Pentaerythritol diacetal	x	x	x	x	x	x	x	-	xx	-	-
Pentaerythritol diisobutyral	-	x	xx	xx	xx	xx	x	-	x	-	xx
Phenyl ether	-	-	-	-	-	x	-	-	xx	-	-
Phenyl sulfide	x	x	xx	xx	xx	xx	xx	-	x	-	xx
Phthalonitrile	-	x	xx	xx	-	xx	xx	-	xx	-	xx
Polyacrylonitrile [1]	-	-	xx	x	-	-	-	-	-	-	-
Sesamin	-	x	xx	x	x	x	x	-	xx	-	x
2-Stilbazole	-	x	xx	x	xx	xx	x	-	x	-	xx
2,4,6-Trinitromesitylene	-	-	-	-	-	xx	-	-	x	-	-
s-Trithiane	-	-	-	-	-	xx	-	-	x	-	-

Table 4. - Adjuncts in nicotine mixtures showing no evidence of synergistic action on insects against which they were tested. (x indicates that a test was made.)

Adjunct	Pea aphid	Armyworm	Southern armyworm	Diamondback moth	Melonworm
Acetone semicarbazone	-	-	x	-	x
Acrylonitrile-dimethylbutadiene copolymer 1/	x	x	-	-	-
p-Aminoacetanelide	-	-	x	-	x
Asarinin	-	-	x	-	x
α-Benzylidenequinaldine	-	-	x	-	x
2,6-Bis(4-chlorostyryl)pyridine	-	-	x	-	x
Blackstrap molasses	-	-	x	-	x
Chlorinated paraffin	-	-	x	-	x
4-Chloroanisole 2/	-	-	x	-	x
α-Chlorobutyronitrile 1/	x	x	-	-	-
β-Cyanoethyl acrylate 1/	x	x	-	-	-
Decyl ether	-	-	x	-	x
Diazoaminobenzene	-	-	x	-	x
3,4-Dibromopyrocatechol	-	-	x	-	x
α,α-Dibromo-2,4,6-trimethylacetophenone	-	-	x	-	x
1,3-Dicyanoguanidine	x	-	-	x	-
Diethyl isopropylidenemalonate	x	x	-	x	-
N,N-Diethyllauramide	x	-	-	x	-
5,6-Dihydro-2,4,6-trimethyl-1,3,5-dithiazine	-	-	x	-	x
N,N-Dimethylcetylamine	-	-	x	-	x
Dimethyl α,β-dichlorosuccinate	x	x	-	x	-
2,4-Dimethyl-3,5-dinitro-phenyl glyoxal monoxime	-	-	x	-	x
N,N-Dimethyldodecylamine oxide	-	-	x	-	x
2,3-Dimethyl-1,4-naphthoquinone	-	-	x	-	x
2,4-Dimethyl-3-pentanone semicarbazone	-	-	x	-	x
Dimethyl phthalate	-	-	x	-	x
2,4-Dinitro-4'-hydroxydiphenylamine	-	-	x	-	x
2,5-Dinitro-4-propyl-m-xylene	-	-	x	-	x
1,5-Diphenyl-3-pentadieneone	-	-	x	-	x
2,6-Distyrylpyridine	-	-	x	-	x

1/ Related to phthalonitrile.

2/ Related to 2,3,4,5,6-pentachloroanisole.

Table 4. - (Continued)

Adjunct	Pea aphid	Armyworm	Southern armyworm	Diamondback moth	Melonworm
Dodecaethyleneglycol monolaurate	-	-	x	-	x
3-Ethyl-5-(α-ethylpropenyl)-6-hydroxy-2-methyl-2,3-dihydrobenzofuran	-	-	x	-	x
2-Ethyl-1,3-hexanediol	-	-	x	-	x
2-Ethoxyethanol in-					
Bentonite	-	-	x	-	x
Pyrophyllite	-	-	x	-	x
Attapulgite	-	-	x	-	x
Hexachlorobenzene	x	-	-	x	-
1-Hexadecanethiol	-	-	x	-	x
Hydracrylonitrile [1/]	x	x	-	-	-
2-Hydroxyethanethiol	-	-	x	-	x
Bis(o-Hydroxyethyl)sulfide	-	-	x	-	x
8-Hydroxyquinoline	x	x	-	x	-
4-Methylcyclohexanone semicarbazone	-	-	x	-	x
N-Methyl-2,2'-iminodiethanol	-	-	x	-	x
2-Methyl-2,4-pentanediol	-	-	x	-	x
10-Nitroanthrone	-	-	x	-	x
p-Nitrobenzenesulfonic acid	x	x	-	x	-
Bis(o-Nitrophenyl)sulfide	x	x	-	x	-
Octadecyl ether	-	-	x	-	x
α,α,2,4,6-Pentamethyl-α,3,5-tribromo-acetophonone	-	-	x	-	x
Pentaerythritol soybean fatty acid monoester	-	-	x	-	x
1,5 Pentanediol bis(phenylurethane)	x	x	-	x	-
1,5-Pentanediol diacetate	x	x	-	x	-
Perthiocyanic acid	x	-	-	x	-
p-Phenylazoaniline	x	x	x	x	x
p-Phenylazoaniline hydrochloride	-	-	x	-	x
o-Phenylphenol in -					
Bentonite	-	-	x	-	x
Pyrophyllite	-	-	x	-	x
Attapulgite	-	-	x	-	x
Phthalamide [1/]	x	x	-	x	-
Polylactic acid (115% lactic acid) in -					
Bentonite	-	-	x	-	x
Pyrophyllite	-	-	x	-	x
Attapulgite	-	-	x	-	x
Sodium ethyl methyl oleylamide sulfonate	-	-	x	-	x

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Table 4. - (Continued)

Adjunct	Pea aphid	Armyworm	Southern armyworm	Diamondback moth	Melonworm
Sorbitol ester of dehydrated castor oil fatty acids	-	-	x	-	x
Sorbitol ester of linseed oil acids	-	-	x	-	x
Sulfonated castor oil (75%)	-	-	x	-	x
Tetrachlorocatechol	-	-	x	-	x
Tetrahydrofurfuryl oleate	-	-	x	-	x
Thiourea	x	-	-	x	-
Tribenzylamine	-	-	x	-	x
2,4,6-Trichloroanisole [2/]	-	-	x	-	x
Tris(p-chlorophenyl)methane	-	-	x	-	x
Triethylaminomethylphenol	x	x	-	x	-
2,4,6-Trimethylacetophenone	-	-	x	-	x
2,4,6-Trinitro-m-xylene	-	-	x	-	x
Triphenylmethane	-	-	x	-	x